KI DATA TOOLING
The Data Kit for Automotive AI

Criteria for Uncertainty-based Corner Cases Detection in Instance Segmentation

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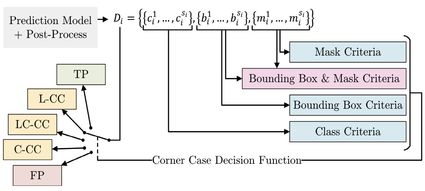


Figure 1: Uncertainty-based corner case detection approach.

Goal

The overall goal of this approach is to identify objects representing a corner cases based on the model uncertainty. To classify the objects into corner case categories without using ground truth labels, extracted features from the determined model uncertainty are used.

Approach

Our approach from Fig. 1 assumes that the object detection model plus a possible post-process (gray) provides several predictions [1, 2], consisting of class score *c*, bounding box *b*, and instance mask *m*, per object detection D_i. The variance in the predictions is used to determine the uncertainty in the machine learning (ML) model. The uncertainty analysis is utilized in the class score, bounding box, and instance mask criteria (blue) or combined in the bounding box & mask criteria (magenta). The values from the criteria are interpreted as features to assign the object detections D_i with a decision function to one of the defined corner case categories.

Corner Case Categories

The defined corner case categories are:

1) True Positive Prediction (TP-P): Class is correctly predicted, and there is a match between detection D_i and ground truth (GT) with an IoU above *0.5*.
2) Localization Corner Case (L-CC): Class is correctly predicted, but the match between detection D_i and GT has an IoU between *0.1* and *0.5*.
3) Classification Corner Case (C-CC): Class is wrong predicted, but the match between detection D_i and GT is still above an IoU of *0.5*.
4) Localization & Classification Corner Case (LC-CC): Class is wrong predicted, and the match between detection D_i and GT has an IoU between *0.1* and *0.5*.
5) False Positive Prediction (FP-P): All detections D_i with an IoU below 0.1, which also includes all detections without a GT match.
6) False Negative Prediction (FN-P): It would be very interesting to know, but there is no way to get this information from the model because there is no prediction to work with.

Dataset Details		COCO	NuImages
Size of Test Subset (Images)		4952	14884
Labeled Objects (Test Subset)		36335	136074
Model Predictions		68660	183597
TP-P	Correct Class & IoU > 0.5	23931 (34,9%)	104980 (57,2%)
L-CC	Correct Class & $0.5 >$ IoU > 0.1	2901 (4,2%)	7837 (4,3%)
C-CC	Wrong Class & IoU > 0.5	1766 (2,6%)	4134 (2,2%)
LC-CC	Wrong Class & $0.5 >$ IoU > 0.1	1257 (1,8%)	2846 (1,6%)
FP-P	No Matches	38805 (56,5%)	63800 (34,7%)
FN-P	Missed Objects	6480	16277
Bounding Box $mAP_{IoU>0.5}$		0.488	0.424
Mask $mAP_{IoU>0.5}$		0.467	0.366

Figure 2: Object categories of predictions from COCO [3] and NuImages [4] based on ground truth label.

Corner Case Criteria

In total we have defined 16 corner case criteria covering class, bounding box, and mask uncertainty feature (see example in Fig. 3&4) and a few to extract uncertainty information from mismatched bounding box and mask pairs. With the corner case criteria as input and the corner case categories (1-5) as label we trained a ML model to predict if an object belongs to any of the defined categories. Fig. 5 shows the confusions matrix of the classification task.

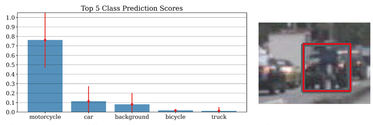
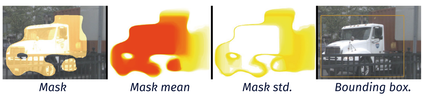


Figure 3: Classification corner case example from NuImages dataset.



Mask *Mask mean* *Mask std.* *Bounding box.*

Figure 4: Uncertainty example from NuImages dataset.

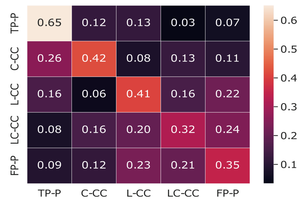


Figure 5: The Confusion matrix of our decision function, using an MLP and the presented corner cases criteria as input, to distinguish objects in TP-P, corner case, or FP-P.

References:

[1] F. Heidecker, A. Hannan, M. Bieshaar, B. Sick, "Towards Corner Case Detection by Modeling the Uncertainty of Instance Segmentation Networks", in Proc. of ICPR, IADS Workshop, Milan, Italy, 2021, pp. 361–374
[2] Heidecker, F. and El-Khateeb, A. and Sick, B.; "Sampling-based Uncertainty Estimation for an Instance Segmentation Network", arXiv preprint arXiv:2305.14977, 2023.
[3] T.-Y. Lin, M. Maire, S. Belongie, L. Bourdev, R. Girshick, J. Hays, P. Perona, D. Ramanan, C. L. Zitnick, and P. Doll´ar, "Microsoft COCO: Common Objects in Context", arXiv preprint arXiv:1405.0312, 2015.
[4] H. Caesar, V. Bankiti, A. H. Lang, S. Vora, V. E. Liong, Q. Xu, A. Krishnan, Y. Pan, G. Baldan, and O. Beijbom, "nuScenes: A Multimodal Dataset for Autonomous Driving," in Proc. of CVPR, Seattle, WA, USA, 2020, pp. 11618–11628.

ML Function Development

Partners

External partners

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